The majority of orchids are tropical plants. However, some orchid species penetrate into high arctic latitudes. Orchid populations have adapted to the life at the northern limit of their existence by the establishment of specific strategies. Long-term studies of orchid demography show that certain traits of development have an effect on the populations of particular species.

Region

Most territory of the Murmansk Region is situated above the Arctic Circle. The Murmansk Region of north-western Russia borders Norway and Finland. This territory encompasses areas of the Kola Peninsula, the Rybachiy Peninsula and also non-coastal areas (Atlas of Murmansk Region, 1971). Historically the larger part of the Region is called Lapland, being the north-eastern part of Fennoscandia. Russians say that it looks like a horse's head. About 9 months of the year is with snow, with only 3 months for a growing period (The agroclimatic review of Murmansk Region, 1961; The review of the climate of URSR, 1965, 1968). A characteristic animal of this climate is reindeer. Diverse landscapes are present in Murmansk Region: mountain areas and tundra, where there are many wetlands.

History

Orchids from the territory of the north-eastern part of Fennoscandia were first mentioned in the XIX century in works of mostly Finnish botanists because that time Finland was a part of Russia (Fellman, 1831; Fellman, 1882; Nylander, 1843-1846; Hjelt, 1889-1926; Kihlman 1890ab; Brotherus, 1896; Cajander, 1906). J.E. Fellman, who compiled the first plant list for this Lapland territory, indicated 9 orchid species (Fellman, 1831). His son, N.I. Fellman, mentioned 11 orchid species in his dissertation (Fellman, 1882). Of them, two species, Herminium monorchis and Chamorchis alpina, were never found again. Furthermore, it is very doubtful that the first one can occur at such latitudes, even in one isolated place. The second one is still cited in all northern "Floras" in spite of the fact it still has not been documented for Murmansk Region (Hylland, 1953; Orlova, 1954; Ramenskaya, 1983; Lid, 1983; Lid, Lid, 1994; Engelskjer, Skifte, 1995). However, Chamorchis alpina may indeed occur in Rybachiy Peninsula from where it is described by the Fellmans because it is typical amphiatlantic species widely distributed on the Scandinavian coast (Hulten, Fries,1986). In other important northern "Floras..." of XIX century 11-14 orchid species are mentioned (Cajander, 1906; Hiitonen, 1933; Hylander, 1953). At the beginning of XX century Finnish-Russian border was very irregular. But after 1920 the frontier became constant and the second wave of exploration of this territory started. It was guided by scientists from St.-Petersburg. In 1931 the Polar-Alpine Botanical Gardens was organized and then transformed into an Institute, PABGI. It was the first botanical gardens in the world north of the Arctic Circle (Luk'yanova, 2003). N.I. Orlova, a scientific researcher of PABGI, revised the orchid family in 1954 for the first "Flora of Murmansk Region" and included 16 species.

Taxa

According to my data 19 orchid species grow in the Murmansk Region (Blinova, 2005). That is a relatively large number compared to the nearest East Russian territories and the reason for such an abundance is the milder climate. Of 35 orchid genera mentioned in the "Flora Europaea" (Tutin et al., 1980), 15 genera are present in the region. Except for Dactylorhiza and Listera, all other genera are unspecific, and very easily determined. Thus, taxonomic studies are not required for orchids growing here. Vice versa, the adaptations of species of mostly tropical family above the Arctic Circle and the population dynamics in the North are of utmost interest.

Distribution

All these orchid species grow at the northernmost limit of their distribution area. There are several types of regional distribution (Blinova, 2005). Only a few of these species grow on the entire Kola and Rybachiy peninsulas. Some reach only central parts of Murmansk Region. The majority, such as Malaxis monophylla, Epiogonium aphyllum, Hammebya paludosum, Goodyera repens, Leucorchis albida have a disjunct ranges, or isolated populations beyond their main range. Such patterns of orchid distribution are primarily influenced by temperature. The southwestern areas get warmer earlier than others in the spring time and in the fall these areas are rather less cold, too (Yakovlev, 1961). That is why most of orchid ranges extend exclusively over southwestern areas. The influence of a warm sea current results in an appropriate climate for the forest vegetation at these latitudes (Zinserling, 1934; Regel, 1935; Chernov, 1953; Mishkin, 1953; Ramenskaya, 1983; Korableva, 1994). Tundra communities are present only along sea coasts and in mountains above the timber line. Most orchids from Murmansk Region are boreal species. They may have a circumpolar or Eurasian range. Only two species - Chamorchis alpina and Leucorchis albida belong to Arctic-Alpine species that occur only in Europe.
Distribution patterns of orchids in Murmansk Region (Russia)

- throughout
  - Corallorhiza trifida
  - Coeloglossum viride
  - Dactylorhiza maculata
  - Gymnadenia conopsea
  - Listera cordata

- southwestern
  - Calypso bulbosa
  - Dactylorhiza longifolia
  - Epipogium aphyllum
  - Listera ovata
  - Platanthera bifolia

- disjunct
  - Epipactis atrorubens
  - Leucorchis albida
  - Cypripedium calceolus
  - Dactylorhiza incarnata
  - Hammarbya paludosa

- western
  - Goodyera repens

- narrow-local
  - Chamorchis alpina
  - Malaxis monophyllos

Epipactis atrorubens

Epipogium aphyllum

Goodyera repens

Gymnadenia conopsea
Life forms

The rhizome and root-tuber life forms are common for orchids growing in Murmansk Region. Only three orchid species have stem-tubers (Malaxis monophyllus, Calypso bulbosa and Hammarbya paludosa) and two others (Corallorrhiza trifida, Epipogium aphyllum) have coraloid-rhizomes.

Ecology

In this region many orchids are boreal and grow in forests composed of Pinus siberiana, Picea obovata and Betula pubescens. Chamorchis alpina and Leuchorchis albida are two species of only of tundra communities. Some species - Dactylorhiza maculata, Gymnadenia conopsea, Coeloglossum viride, Listera cordata - are frequent in both tundra and forest and in the azonal communities like bogs.

Orchid populations at the northern limit of their distribution

Populations of 16 orchid species with various life forms have been investigated. Long-term studies have been conducted during 2-14 years on marked individuals. Among the most and the longest studied are the populations of Cypripedium calceolus, Platanthera bifolia, Coeloglossum viride, Calypso bulbosa and Epipogium aphyllum. At the northern limit of the distribution 50% of orchid populations studied restrict their occurrence to very small areas. For instance, one population of Hammarbya paludosa grows within 1 m² (Blinova et al., 2002, Blinova, 2003a). The density of individuals in such isolated populations can reach the similar average level compared with the populations in central parts of their distribution.

The regression model applied to assess the future development of populations in long-term studies revealed a positive forecast for 60%. A negative trend is found for 40% of studied populations, which is more common in populations of rare species throughout the whole range - Hammarbya paludosa, Epipogium aphyllum and rare in the north species - Dactylorhiza incarnata, Listera ovata. Annual trends of population fluctuations are less connected with life form of the species but are species specific and thus not easily explained only by temperature.

The composition of different-aged individuals in population, the so called ontogenetic spectrum, with the predominance of vegetative plants, is characteristic for the majority of orchid populations. Ontogenetic structure of orchid populations reflects their strategies. At the northern limit of the distribution, the orchids of the same life form have one or two basic ontogenetic spectra. The presence of young plants is relatively low in northern populations of rhizome, root-cluster and stem-tuber
orchids (up to 10%) and it is more significant in populations of root-tuber species (up to 30%).

Reproductive success & pollination

It is predicted that the auto-pollination is more significant for temperate orchids than for tropical orchids (Catling, 1990). But the populations of only one orchid species - *Goodyera repens* - are seen to be obligately auto-pollinated. Other orchids in the North are pollinated by insects. It is possible to distinguish four groups among them: with the high (32%), middle (25%), low (25%) fruit to flowers ratio and those without fruit formation (13%). So, the limitation of pollinators is one of the pronounced bottlenecks in the populations' development. My experiments on artificial pollination in the populations with very low percentage of fruits (*Cypripedium calceolus*) or in those with no fruit production at all (*Epipogium aphyllum*) revealed almost 100% pollination success (Blinova, 2002).

Northern strategies & species' individualism

One of the basic characteristics of orchid individuals in northern populations is small size. This is because of the reduction of shoot units (so called metamere) and the number of flowers (Blinova, 2004). However, it is very difficult to find common features in the development of populations themselves. Many of them reside in the central parts of their distribution, in large areas with uncertain borders (stable populations) which become local and restricted on very small places at the northern limit of distributions. The number of vegetative individuals prevails over the generative individuals. The attempts to explain population biology of orchids only by their life forms or origin fail often. My long-term studies show that many orchid populations express individualistic traits. Two examples are *Cypripedium calceolus* & *Listera ovata*. Both species are short-rhizome orchids with a Eurasian range. However, in the North, in populations of *C. calceolus*, vegetative individuals prevail but in *L. ovata* populations the generative individuals dominate. The lack of pollinators causes the low percentage of fruiting in populations of *C. calceolus*, whereas the fruit formation is always high in populations of *L. ovata*.

On the other hand, the enhancement of fruits by the artificial pollination in populations of *C. calceolus* has triggered the appearance of young individuals. Vice versa, the high seed production of *L. ovata* has no reflection in the number of seedlings - they are almost always absent! Consequently, the problem may be the difference in seed germination of the two species.

Another example involves two species from the same genus *Dactylorhiza*: *D. incarnata* - *D. maculata*. Both have the same root-tuber life form and both are Eurasian. *D. incarnata* has very high fruit production, whereas the number of fruits varies in *D. maculata*. In spite of this fact, the number of seedlings is always high in populations of *D. maculata* and very low in populations of *D. incarnata*. Besides, my recent studies in populations of *D. incarnata* have revealed the high cost of reproduction being the long-time (3 years and more) vegetative stage after a single flowering and fruiting. This trait has never been observed in populations of *D. maculata*.

The orchid populations' individualism creates additional problems for nature protection because the common measures being applied for related species or for the species of the same life form appear to be not effective. The best method seems to be the long-term monitoring (10 and more years) of populations of specific orchid species conducted on marked individuals (Blinova, 2003b).

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**Plant names are given according to Cherepanov (1995)**

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